Abstract – In order to assist decision-makers towards the management of coastal transitional waters, we tested the potential of three benthic indices (AMBI, M-AMBI and BITS) in hundreds stations from Italian CTEs, from the Northern Adriatic to Sardinia. Our study highlights i) a high correlation between AMBI and BITS results, despite the different level of taxonomic identification needed, ii) a high correlation between M-AMBI and species’ diversity and richness, iii) that M-AMBI overweights the number of species since in its calculation they are counted twice, iv) that M-AMBI acts as a “diversity-corrected AMBI”, and, thus, v) it suffers of the reduction of species number along the transitional gradient. This study suggests that in such environments M-AMBI classification seems unable to capture some peculiarities of benthic assemblages in transitional waters. The unmodified use of these indices might impair accurate assessment of ecological quality status and decision-making on the managers’ point of view.

Key-words: biodiversity, environmental management, coastal transitional ecosystems.

Introduction - Italian coastal transitional ecosystems (CTEs) exhibit different and peculiar characteristics depending on their geographical, hydrodynamic and ecological features, and are characterised by progressive changes in several environmental variables, often mutually dependent or correlated. These variations generate composite gradients that involve salinity, marine water renewal (e.g. residence time), nutrients, turbidity and sediment structure. (Tagliapietra et al., 2009). CTEs also display distinctive features in terms of their extraordinary history of environmental management, the importance of their productivity and associated economical value, which is reflected on the peculiarity of their fauna (Cognetti and Maltagliati, 2008). Along Italian coasts there are almost 170 CTEs, but 140 of them have a surface area <10 km². With the exclusion of Orbetello Lagoon (Central Tyrrenhian Sea), all the largest CTEs are located along the Western Adriatic coasts, and, apart the Apulian Lesina and Varano Lakes, they are all concentrated in the Northern Adriatic area. This study represents a contribution towards the assessment of the potential of benthic indices for environmental quality assessment of Italian CTEs.

Materials and methods – We used soft-sediment benthic macrofaunal inventories gained through several research programs that we carried out on several CTEs located along the Italian coasts: Venice Lagoon, Sacca di Scardovari, Sacca di Goro, Valle di Gorino, Valli di Comacchio (Northern Adriatic), Lesina Lagoon (Southern Adriatic), S.Giusta and Cabras Lagoons (Sardinia Island). The macrofauna was collected with a Van Veen grab (area: 0.027 m²; volume: 4 l) in triplicate. Taxonomic identification was carried out to the species level whenever possible. Abundance of species at each sample was averaged for each station at each sampling time, leading
to a total number of over 400 stations. Three different biotic indices were calculated for each site, namely AMBI (Borja et al., 2000) and M-AMBI (Muxika et al., 2007), and BITS (Mistri and Munari, 2008). AMBI and M-AMBI were calculated using the freeware program available on www.azti.es. For M-AMBI, reference conditions were: status High, muddy habitats: AMBI=1.67, Diversity=3, Richness=37; sandy habitats: AMBI=1.54, Diversity=3.93, Richness=39; status Bad, all habitats: AMBI=6, Diversity=0, Richness=0. BITS was calculated using the freeware program available on www.bits.unife.it. Regression between indices was performed not using the EcoQ status but the numerical score of each index in each station. Significance was assessed through regression ANOVA. Finally, the relationships between different indices and benthic community attributes were also investigated by means of regression analysis and ANOVA.

Results - Because of the physiographical characteristics of Italian CTEs (closed lagoons have no sandy bottoms, while in semi-closed lagoons sand is found only in proximity of seamouths), the majority of our stations were on mud. Annelida largely dominated in both habitats: *Polydora ciliata*, *Capitella capitata*, *Heteromastus*

![Fig. 1 - Example of relationships between M-AMBI and BITS with diversity in the Po Delta stations.](image)

_Esempio della relazione tra M-AMBI e BITS con la diversità nelle stazioni del Delta del Po._
*filiformis*, *Streblospio shrubsolii*, *Prionospio caspersi*, *Spio decoratus*, *Neanthes succinea* and *Tubificoides vestibulatus* were the most common taxa. Among Crustacea, *Corophium insidiosum* was often recorded with elevated dominance at stations characterized by freshwater inputs, and Gammaridea (*Microdeutopus gryllotalpa*, *Gammarus insensibilis*) were often found associated to macroalgae (mostly *Gracilaria* sp. and *Ulva* sp.). The snail *Hydrobia ventrosa* was often abundant on decaying macroalgal remnants. On mud, richness and diversity were lower, and generally fewer taxa resulted as dominant. Regression between indices allowed us to assess whether the different indices displayed similar tendency in the classification of sites, i.e. it permitted to assess if two indices ranked the sites from worst to best in the same way regardless of the precise classes of EcoQ. Linear regression of BITS and AMBI/M-AMBI accounted for 44% and 36% of the variability of the entire dataset, respectively, with quite a low degree of dispersion over the entire range of both indices. The ANOVA of both regressions was highly significant. It meant that the BITS, AMBI and M-AMBI indices basically ranked stations in the same way from worst to best ecological condition. Only M-AMBI evidenced a very strong relationship with diversity (Fig. 1) and richness, with a low degree of dispersion of points on the graphs. This observation may seem quite trivial, since diversity and richness are the two metrics, together with AMBI, used in the multivariate formulation of M-AMBI. On the other hand, BITS and, to a lesser extent, AMBI showed quite a clear “tendency” to increase (the former) and decrease (the latter) with increasing diversity and richness.

**Conclusions** – This study provides a good example from a comprehensive large dataset of the levels and ranges of benthic pattern which can be encountered in Italian coastal transitional ecosystems. The pattern of ecological quality status of Italian CTEs obtained by applying three benthic indices was not always concordant, depending to the index selected. In spite of their diversity, these indices are based on the same paradigm: disturbances are generating secondary successions during which tolerant species are at first dominant and then progressively replaced by sensitive species (Pearson and Rosenberg, 1978). In CTEs, an index to be useful should display some “plasticity” in considering anthropogenic or natural disturbance. Ruellet and Dauvin (2007) argued that the inclusion of Shannon diversity and species richness in M-AMBI computation gives too much weight to diversity. Results from this study confirm previous observations (Ruellet and Dauvin, 2007) in Adriatic CTEs, and add the hypothesis that M-AMBI robustness is reduced under low salinity conditions. Conversely, AMBI and BITS, giving no weight to diversity but considering only the ecological meaning of species (or families) produced different classifications respect M-AMBI. In transition environments, chemical-physical parameters can represent limiting factors for species. In particular, salinity plays the most important role, since the distribution of organisms can be established in relation to isohalines (Cognetti and Maltagliati, 2000). The steno and euhaline species living in these environments follow a gradient of resistance to the increasing environmental stress, and at a critical salinity level (5-10 psu) there is a sharp numeric drop in species richness (Cognetti and Maltagliati, 2000). The distribution pattern of the benthic fauna is similar to that found in polluted waters, since diversity and richness tend to decrease towards the source of disturbance, according to the Pearson and Rosenberg (1978) paradigm. But, as remarked by Cognetti and Maltagliati (2000) the difference as compared to CTEs lies in the fact that the maximum critical point in polluted waters corresponds to disappearance of the fauna, while in CTEs to a community made up of few taxa better adapted to low (or very variable) salinity. M-AMBI classification is
too much dependent on diversity and richness, and seems unable to capture some peculiarities of benthic assemblages in transitional waters. On the other hand, AMBI and BITS gave often similar classifications, despite the different level of taxonomic identification needed (at the species level for AMBI and at the family level for BITS). Our study highlights i) a high correlation between AMBI and BITS results, ii) a high correlation between M-AMBI and species’ diversity and richness, iii) that M-AMBI overweights the number of species since in its calculation they are counted twice, iv) that M-AMBI acts as a “diversity-corrected AMBI”, and, thus, v) it suffers of the reduction of species number along the transitional gradient. Finally, most benthic indices require the use of the species level as the level of identification. According to the taxonomic sufficiency principle it is possible to use the genus or the family level of identification, thus reducing the cost of obtaining results in routine monitoring programs. Despite the AMBI check-list contains the benthic taxa at the species level, the taxonomic sufficiency principle is already present in the list since it also provides the ecological status of most of the genus, families and also higher taxonomic levels (e.g. *Hydroides dianthus*, *Hydroides* sp., Serpulidae; *Tubificoides swirencoides*, *Tubificoides* sp., Tubificidae, Oligochaeta; *Heterotanais oerstedi*, *Heterotanais* sp., Tanaidacea; etc.). A genus or family level of identification for the WFD implementation in the benthic compartment of Italian CTEs might be sufficient for evaluating the status of such water bodies.

References